NOTES ON AUSTRALIAN CHAETOGNATHA.

By Professor T. Harvey Johnston, M.A., D.Sc., and B. Buckland Taylor

(Biology Department, University, Brisbane.)

(Text-figures 1-4.)

(*Read before the Royal Society of Queensland, 28th April*, 1919).

The Chaetognatha of the Australian coast have received very little attention. Apart from the collection made in Shark Bay, Western Australia, reported on by Ritter-Zahony (1910), no systematic attempt to investigate them seems to have been made.

No records have been published regarding their presence on the northern and southern coasts, though several species, viz., *Sagitta hexaptera*, *S. serratodentata* and *Eukrohnia hamata* have been reported from Antarctic waters due south of Australia (Fowler, 1907). A few casual determinations of species from the Eastern coast have been made by Ritter-Zahony in 1909 (*S. bipunctata*, *S. serratodentata* and *S. robusta*), and Johnston in 1909 (*S. australis*). Whitelegge (1889. p. 163) mentioned the occurrence of *Sagitta* sp. in Sydney Harbour, while Waite* reported that *Sagitta* was taken commonly in tow nets by the Thetis Expedition off the N.S.W. coast. Steinhaus recorded *S. enflata* from 160° E, some distance westward of New Caledonia, but the record cannot be considered as Australian. Ritter-Zahony (1909 p. 792) referred to the

* E. R. Waite, Memoirs Austr. Museum, 4 (1), 1899, p. 14.

capture of *S. enflata* forma *minor* by the "Gazelle" during a voyage between the Solomon Islands and Moreton Bay, but this record is not sufficiently localised to be regarded as Australian. *S. hexaptera* is known from New Guinea and New Britain (Ritt.-Z. 1909, p. 790).

We have examined tow-net material from Moreton Bay and Port Jackson, as well as that collected by Professor Haswell, F.R.S., in the s.s. "Miner," in June, 1906, at a locality fifty miles E. of Sydney. We take this opportunity to express our indebtedness to Professor Haswell.

To the three species of Chaetognatha reported from Eastern Australian waters, we are able to add six species of *Sagitta* and one of *Spadella*. The total number of species now known from the Australian coast is as follows: *Sagitta* eleven; *Pterosagitta* one; *Krohnitta* one; *Spadella* one; total fourteen.

Under each heading we have mentioned some of the outstanding features by which the species may be readily determined. A list of measurements is appended, and a simple key to the recorded Australian forms, which we have found to be of service, has been added for the convenience of Australian students.

1. *S. serratodentata* Krohn.

Syn: *Spadella serratodentata* Grassi, 1883.

We have examined a good many specimens of the species, and have found a considerable range of variation in the number of anterior and posterior teeth, and in the relative size of the jaws. Our specimens have from 2 to 3 anterior and 4 to 12 posterior teeth as compared with 8 to 10 and 17 to 20 respectively, as recorded by Fowler (1906, p. 20) and 6 to 9 anterior, 13 to 19 posterior, as recorded by Michael (1911, p. 39). The fins of the specimens were very torn, which probably accounts for the fact that we found less than 50% of the posterior fin on the body. Michael (1911 p. 39) has referred to the variability of this ratio. In a few of our specimens, which were very small, being less than 5mm. in length, some of the jaws were

slender and apparently not serrated. Tactile papillae were present on nearly all, and in the mature forms the tail was filled with sperm morulæ.

Australian localities: Port Jackson (June, 1907); also Shark Bay, Western Australia (Ritter-Zahony, 1910, p.126); Great Sandy Island, Queensland (Ritt.-Z., 1909, p. 792).

Also recorded from the Atlantic Ocean; the East Indies; Japan; the Maldives; the Indian Ocean: the Mediterranean Sea; Southern California; the Straits of Magellan.

2. *S. australis* Johnston.

We have re-examined specimens of this species, declared by Ritter-Zahony (1911, p. 13) to be a synonym of *S. enflata*, and have come to the conclusion that the species is valid. There are four transparent, flaccid species with which it might at first sight be confused, but from all of which it is distinguished by the possession of a bilobed tail. They are *S. enflata*, *S. hexaptera*, *S. pulchra*, and *S. lyra*.

From *S. enflata* it differs markedly in the relative positions of the anterior fin and ventral ganglion. Ritter-Zahony (1911, p. 13), says, "Vorderflossen schmal, abgerundet, von Bauchganglion um dessen mehrfache Lange entfernt," which is borne out by his diagram in which the interval between the two is at least the length of the fin. As shewn in the original figure of *australis* (Johnston, 1909), the anterior fin begins in *front* of the ganglion. There is also a difference in the position of the widest portion of the posterior fin, this being at the tail septum in *enflata*, but behind the septum in *australis*. Again, the former has a small collarette, but no such structure has been observed in the latter.

From *S. pulchra* it is distinguished by the well marked neck, the presence of rays in the fins; also the maximum number of jaws in *pulchra* (7) is the minimum in *australis* (7-11); the tail percentage is lower in *australis* (16.5%, as compared with 18% in *pulchra*).

From *S. hexaptera* it differs in the number of anterior teeth (1-4 *hexaptera*; 6-12 *australis*); in the number of

posterior teeth (1-6 *hexaptera* ; 9-11 *australis*) ; the anterior fin is remote from the ganglion in *hexaptera* and there is a greater distance between it and the posterior fin (11% compared to 8% in *australis*) ; there is also a difference in the relative length of the two fins, the posterior being the longer in *hexaptera*, but in *australis* they are equal, or the anterior may be slightly the longer ; a crest is present on the jaws of *hexaptera* but not on those of *australis* ; the latter is also distinguished by its marked neck.

From *S. lyra* it differs in the number of anterior teeth (4-8, *lyra*) ; in the position of the widest part of the posterior fin (in front of the septum in *lyra*) ; in the lesser distance between the fins (6.1% *lyra*) and in its well marked neck.

Australian record : Maroubra Bay, near Sydney, N.S.W. (Johnston, 1909).

3. *S. enflata* Grassi.

Syn : *S. lyra* Langerhans, 1880 (not Krohn, 1853). ;
Spadella enflata Grassi, 1881 ;
S. flaccida Conant, 1896 ;
S. gardineri Doncaster, 1902 ;
S. brachycephala Moltschanoff, 1907 ;
S. inflata Ritter-Zahony, 1908, 1909.

Body broad, transparent and flaccid ; neck marked ; anterior fin does not reach ventral ganglion. Posterior fin does not reach seminal vesicles but tail fin does. Very like *S. australis* in general appearance but the differences have been discussed under *S. australis*.

Australian localities : 50 miles E. of Sydney (common, June, 1906) ; Southport, Moreton Bay, Queensland, (Feb. 1919) ; already reported from Shark Bay, W.A. (Ritter-Zahony, 1910). Also recorded from the North Atlantic ; Mediterranean Sea ; Madeira ; Japan ; Indo-Pacific ; Maldives ; East Indies ; Southern California.

4. *S. pulchra* Doncaster.

We have identified this species from a solitary immature specimen. It is a transparent, flaccid form with numerous sensory papillae distributed over the entire

animal. From the posterior end of the tail to the ganglion is 67% of the total length. A collarette is present.

Australian localities: Tasman Sea, 50 miles E. of Sydney—previously reported from Shark Bay, W. A. (Ritter-Zahony, 1910). Also recorded from New Guinea; the East Indies; Indo-Pacific; Maldives; and the North Pacific.

5. *S. minima* Grassi.

Syn: *Spadella minima* Grassi, 1881.

Transparent and comparatively stout, with a neck region visible, though there is no marked constriction. In one of our specimens, which was almost mature, the ovaries were compact and club-shaped, the whole tail filled with developing spermatozoa; the seminal vesicles, however, were very small. There is no constriction at the septum, but the decrease in size is rather sudden. 20% is the maximum tail percentage recorded, but one of our specimens has a percentage of over 23%. The anterior fin almost reaches the ganglion.

Australian localities: 50 miles E. of Sydney (June, 1906); already known from Shark Bay, W.A. (Ritter-Zahony, 1910). Also recorded from Japan; Indian Ocean; Mid Atlantic; and the Mediterranean Sea.

6. *S. bedoti* Beraneck.

Syn: *S. bipunctata* Aida, 1895.

S. polyodon Doncaster, 1902.

This form is not among our Eastern Australian material the following information being taken from Michael (1911, p. 75). No collarette; head small; sudden diminution at tail septum; anterior fin longer than posterior; posterior fin extends to seminal vesicles; less than 50% of posterior fin in front of tail septum.

Australian localities: Shark Bay, W.A. (Ritter-Zahony, 1910). Also recorded from the East Indies; Japan: Indo-Pacific; Maldives (as *S. polyodon*).

7. *S. regularis* Aida.

Syn: *S. bedfordii* Doncaster, 1902.

We have examined only one immature specimen,

comparatively slender, firm and opaque, with a fairly uniform breadth to the septum. The corona ciliata is entirely on the body ; a very noticeable collarette is present extending over the whole head ; and apparently there is a thickening of the epidermis all over the body, bearing numerous tactile papillae.

Australian localities : 50 miles E. of Sydney (June, 1906) ; known also from Shark Bay, W.A. (Ritter-Zahony, 1910). Also recorded from the East Indies ; Japan, Indo-Pacific ; Maldives.

8. *S. robusta* Doncaster.

Syn : *S. hispida* (non Conant) Aida, 1897 ;
S. hispida Doncaster, 1902 ;
S. ferox Doncaster, 1902 ;
S. japonica Galzow, 1910.

A firm opaque form, about the same width from the ganglion to septum ; many sensory papillae over whole body and tail ; collarette marked, though not so conspicuous as in *regularis*, extending to the anterior fin ; the posterior fin reaching the characteristically shaped seminal vesicles in mature specimens, as does also the tail fin ; the jaws thick at the base and greatly curved in the terminal third ; lateral process of vestibular ridge blunt ; papillae irregular and rather pointed.

Australian localities : 50 miles E. of Sydney (June, 1906) ; reported also from Great Sandy Island, Queensland (Ritter-Zahony, 1909). Also recorded from New Guinea ; East Indies ; Sea of Japan ; Indian Ocean ; Maldives ; Atlantic Ocean.

9. *S. bipunctata* Quoy and Gaimard.

Syn : *S. multidentata* Krohn, 1853 ;
Spadella marioni Gourret, 1884.

This form was not found among our Eastern Australian material, the following information being taken from Michael 1911, p. 41). Body rigid ; constriction at tail septum evident ; collarette very short ; anterior fin never extending to ventral ganglion ; posterior fin longer than anterior,

extending to seminal vesicles when the latter are tumid, being always more than 50% of fin in front of tail septum.

Australian localities : Great Sandy Island, Queensland (Ritter-Zahony, 1909 ; Shark Bay, W.A. (Ritter-Zahony, 1910). Also recorded from New Guinea ; Altantic Ocean ; North Sea ; Baltic Sea ; English Channel ; Irish Sea ; Mediterranean Sea ; Carribean Sea ; Indo-Pacific ; Bay of Bengal ; Southern California ; S. of the Cape of Good Hope ; Arctic Ocean.

10 *S. tenuis* Conant.

This species is placed by Ritter-Zahony in the synonymy of *S. bipunctata*, but Michael (1911, p. 72) declares it distinct. We refer to this species a solitary specimen which is opaque and firm, and more or less of even width. It is impossible to make out the limits of the fins, but all other measurements coincide with those of *S. tenuis*, though our specimen is 0.5mm. longer than any other recorded. There is a small collarette, a few papillae, and no neck ; the tail is full of sperm morulae. It should be borne in mind that Ritter-Zahony has already recorded *S. bipunctata* from Great Sandy Island, on the Queensland coast.

Australian locality : Port Jackson (June, 1907). Previously recorded from Jamaica by Conant.

11. S. *neglecta* Aida.

Syn : *S. septata* Doncaster, 1902.

Our specimens ranged from 3.6 to 5.2mm. in length, none of which were fully mature. They were slender, firm and opaque. A collarette was visible on several. The anterior fin reached the seminal vesicles. There was less than 50% of the posterior fin in front of the tail septum. The fins were imperfect in all our material, which will account for the great variation in the interval between the fins as recorded in our table.

Australian localities : Caloundra and Southport, Moreton Bay, Queensland, May, 1918, Feb., 1919. Also recorded from the Indo-Pacific : Maldives ; Japan : East Indies ; Southern California.

12. *Pterosagitta draco* (Krohn).

Syn : *Pt. mediterranea* Costa, 1869 ;
Sagitta draco Krohn, 1853 ;
Spadella draco of authors ;
Spadella vaugai Beraneck, 1895.

This species was not present in our Eastern Australian material, the following description being taken from Michael (1911, p. 54). Body firm and opaque ; collarette very pronounced, measuring approximately 0.5% on each side of the body, and extending from head to tail septum ; ventral ganglion midway between head and tail septum.

Length 7mm. ; tail 43.6% ; tail to ventral ganglion 66% : anterior teeth 4-8 ; posterior teeth 8-18 ; jaws 8-10.

Australian locality : Shark Bay, W.A. (Ritter-Zahony, 1910). Also recorded from the Atlantic Ocean ; Mediterranean Sea ; Indian Ocean ; Maldives ; Japan ; Southern California ; Agulhas ; Antarctic.

13. *Krohnitta subtilis* (Grassi).

Syn : *Sagitta subtilis* Grassi, 1881.
Spadella subtilis Grassi, 1883 ;
Krohnia subtilis Strodtmann, 1892 ;
K. pacifica Aida, 1897 ;
Eukrohnia subtilis (Grassi).

This species was not among out Eastern Australian material, the following description being taken from Michael (1911, p. 52). Body nearly transparent, long and slender ; neck evident ; seizing jaw very flat, broad, thin and evenly curved, points extremely fine and delicate.

Length 12-16mm. ; tail 30-34% ; to ventral ganglion 17-23% ; teeth 10-14 ; jaws 7-9.

Australian locality : Shark Bay, W.A. (Ritter-Zahony, 1910). Also recorded from the Atlantic Ocean ; Black Sea ; Mediterranean Sea ; Indian Ocean ; Bay of Bengal ; Southern California.

TABLE OF CHARACTERS OF SPECIES OF SAGITTA (recorded from Australian waters).

( ) denotes information obtained from the following sources: Fowler (1906); Michael (1908); and Ritter-Zahony (1911).

	Length in mm.	% of total length.				Anter. teeth	Poster. teeth	Jaws
		Tail	Ant. fin.	Post. fin.	Dist. bet. fins			
S. serratodentata	3.4–16 (17)	20–30 (36)	(20–24)	14–17 (25)	(7.5)	2–3 (11)	4–12 (20)	6–7 (8)
S. australis.. ..	12–24	16–17	20–28	20.8	8	6–12	7–11	9
S. enflata	17.5 (20)	13–20 (25)	11–17	17	6.8	10	15 (17)	7–8 (10)
S. pulchra ..	5–8 (22)	27.5	(34.6)	(24)	(5.7)	(5–10)	(9–19)	11
S. minima ..	4.8–6 (10)	19–23				(3–5)	(7–14)	6–7 (8)
S. bedoti	(5–18)	(21–35)	(20)	(24)	(5.4)	(9–13)	(20–23)	(5–7)
S. regularis ..	5.8 (27)	29 (40)	(13)	(23)	6.8	(2–4)	(2–6)	9
S. robusta ..	14–16 (20)	20–29 (36)	14–17 (20)	18–24	10–12 (6.8)	6–7 (10)	10–13 (16)	8–9
S. bipunctata ..	(9–20)	(21.27)	(15–9)	(7.9)	(17)	(4–8)	(8–18)	(6–9)
S. tenuis	6	28.3 (29)	(12–13)	(25.6)	(16–17)	(5)	(9)	8
S. neglecta ..	3.6–5 (10)	24–32.8 (40)	11–18.4 (21)	17.6–23	6.4–11	2–4 (7)	6–10 (18)	6–7 (8)

14. *Spadella moretonensis* n. sp. (Text-figures 1-4).

A small robust species, 3.68mm. in length, with a pronounced neck region, which is masked by an extensive collarette, reaching the lateral fins and having a swelling on either side of the position of the corona, so that the neck region here appears almost as wide as the head. There are transverse muscles present throughout both body and tail, and the whole animal is covered with sensory papillae, each bearing several short tactile setae. The head is slightly broader than it is long, and has two prominences in front, each bearing 3 or 4 very stout curved teeth

measuring .03mm. in length; the eyes are large but not pigmented. There are 9 jaws on each side, in form like those of *Eukrohnia subtilis*, the point not being inserted into the shaft, but they are more curved. The corona is almost circular, and lies on the neck and body. The animal is widest at the septum, where it measures (excluding fin) 0.4 mm. *i.e.*, 11.7% of the total length, and then tapers gradually towards the neck and tail. The lateral fin commences on front of the receptaculum seminis. It reaches its maximum width (which is 18% of the total length of the animal including the tail fin) in front of the tail, then narrowing in the region of the seminal vesicles, where it becomes confluent with the tail fin. The latter, as well as the lateral fins are entirely traversed by rays. The ovaries extend into the vicinity of the ganglion the ova being few and relatively very large (0.2mm.) A small receptaculum seminis opens on the dorso-lateral surface on each side just in front of the tail septum. The aperture is situated on a well-marked rounded prominence with a swollen extremity and a rather narrower stalk-like portion. The actual opening is trilobed in our specimen. The tail measures 56.5% of the total length. Most of its coelome is filled with sperm morulæ, the testis occupying only a small anterior position. The vesiculæ seminales are very small and inconspicuous, and lie in the posterior third of the tail, at the narrowest part of the fin width. The tail fin arises from the dorsal surface and there is a differentiated zone at the posterior end of the tail. There are sensory patches on both the lateral and tail fins. Two club-shaped papillated bodies are present on the posterior half of the tail, lying on the ventral surface at the right side. Though they became stained like the tissues of the animal, as a result of the use of hæmatoxylin, yet their asymmetrical arrangement and general appearance suggest that they are foreign bodies—perhaps of an algal nature. The largest measures 0.14mm. in length and 0..06mm. in maximum breadth; the other 0.10 and 0.04mm. respectively.

The following measurements were taken from the animal while in formalin; Length, including tail fin, 3.68 mm.; tail, 56.5% of total length; maximum breadth,

excluding lateral fin, 11.7% of total length; maximum width of fin, 18.2% of total length; percentage of fin in front of tail septum, 3%; tail, including tail fin, to ventral ganglion, 75% of total length.

Sp. moretonensis differs from the other two valid species of *Spadella* in the following characters:—

Sp. schizoptera Conant, possesses two pairs of fins, its corona is triangular, its teeth are long and curved, and the tail is 51% of the total length.

Sp. cephaloptera Busch, possesses two rows of teeth, the fin begins behind the receptaculum seminis, the corona is a long oval and the collarette covers the whole body. The possession of a club-like tentacle on each side of the head is quoted as one of the distinguishing characters of the species. These however do not appear to have been seen by subsequent observers, at least some of whom have assumed that they had become lost from the specimens which they examined. The figures of *Sp. cephaloptera*, which are available to us, and which show the presence of these structures, suggest that they are probably not tentacles but are foreign organisms, probably algæ, which have accidently developed symmetrically on the head region. They remind us of the two club-like bodies present on our solitary specimen of *Sp. moretonensis*.

The known range of *Spadella* (sensu stricto) is as follows:—*Sp. cephaloptera*, Atlantic and Mediterranean coast of Europe, the Black Sea and the Irish Seas. *Sp. schizoptera* is known only from the Bahamas. *Sp. moretonensis* is the first species of the genus to be recorded from the Southern Hemisphere.

We take this opportunity to express our thanks to Mr. R. L. Higgins for this specimen, which was found among algæ at Caloundra, July, 1918.

KEY TO GENERA OF CHAETOGNATHA.

From Ritter-Zahony (1911, p. 44).

1. Transverse muscles on body.....2
   No transverse muscles on body.....4

2. Medium sized species, with 1 or 2 rows of numerous teeth on each side, and an extensive pair of fins extending over body and tail.....3
   Small compact species with 1 or 2 rows of small teeth, a pair of fins on the tail, and may have a second small pair of fins on the body.....*Spadella*

3. Two rows of teeth on each side, transverse muscles in anterior third of tail.....*Heterokrohnia*
   One row of teeth on each side, small transverse muscles in tail.....*Eukrohnia*

4. One row of slender converging teeth on each side, one pair of lateral fins.....*Krohnitta*
   Two rows of conical teeth on each side.....5

5. Two pairs of lateral fins, sometimes fused together.....*Sagitta*
   One pair of lateral fins on the tail, as the continuation of a voluminous collarette.....*Pterosagitta*

KEY TO SPECIES OF SAGITTA

recorded from Australian waters.

1. Body transparent and flaccid 3
2. Body firm and opaque.....6
3. Neck constriction very marked.....4
   Neck constriction not marked.....5
4. Anterior fin extends in front of ganglion.....*australis*
   Anterior fin does not reach ganglion .....*enflata*
5. Collarette present .....*pulchra*
   Collarette absent.....*minima*
6. Teeth serrated.....*serratodentata*
   Teeth not serrated.....7
7. Posterior teeth more than 20.....*bedoti*
   Posterior teeth fewer than 20.....8
8. Collarette extends over whole head and to anterior fin.....*regularis*
   Collarette extends from behind head to anterior fin.....*robusta*,
   Collarette very small.....9
9. Posterior fin extends to seminal vesicles.....*bipunctata*
   Posterior fin does not extend to seminal vesicles.....10
10. Anterior fin less than 15% total length.....*tenuis*
    Anterior fin more than 15% total length.....*neglecta*

BIBLIOGRAPHY.

1906 Fowler, G. H.—Chaetognatha of the Siboga Expedition, etc. Siboga Expedition Monograph, 21, 1906.

1907 Fowler, G. H.—Chaetognatha with a note on those collected by H.M.S. "Challenger," etc. National Antarctic Exp. Nat. Hist., Vol. 3, 1907, 6 pp.

1909 Johnston, T. H.—An Australian Chaetognath. Records of the Australian Museum, 7, (4), 1909, pp. 251-6.

1908 Michael, E. L.—Notes on the identification of the Chaetognatha, Biol. Bull, 15, (2), 1908, pp. 67-84.

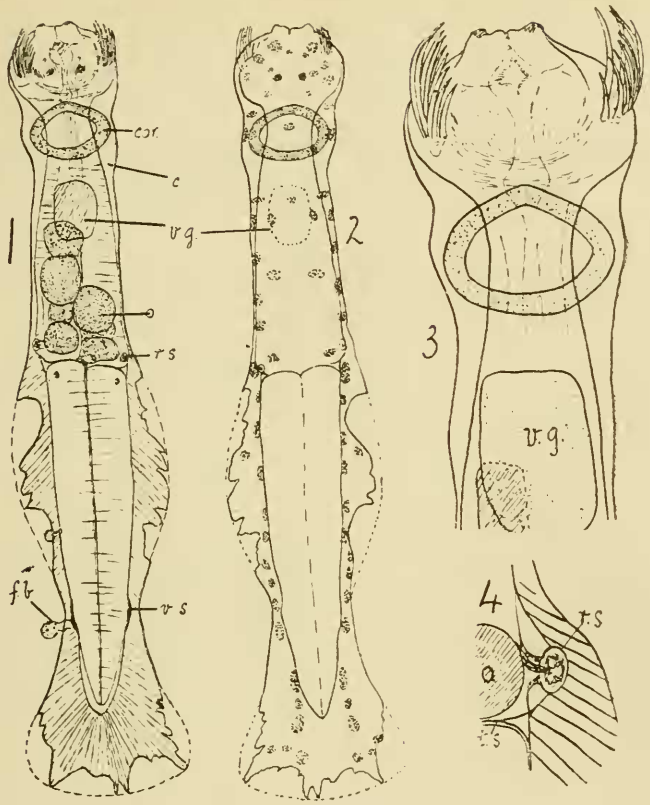
1911 Michael, E. L.—Classification and vertical distribution of the Chaetognatha of the San Diego region. University of California publications in Zoology, 8, (3), 1911, pp. 21-186.

1909 Ritter-Zahony, R. von—Die Chaetognathen der Gazelle Expedition, Zool. Anz. 34, 1909.

1910 Ritter-Zahony, R. von—Chaetognatha. Fauna Sud-West Australiens, 3, (3), 1910, pp. 125-6.

1911 Ritter-Zahony, R. von—Revision der Chaetognathen. Deutsche Sud-polar Exped., Vol. 13, Zool., Vol. 5 (1).

1889 Whitelegge, T.—List of marine and invertebrate fauna of Port Jackson, etc., P.R.S. N.S.W., 23, 1889.



TEXT-FIGURES, 1-4.

Text-figure 1.—Entire specimen of *Spadella moretonensis*, viewed from the ventral surface as a transparent object; sensory areas omitted.

Text-figure 2.—Dorsal view to show arrangement of sensory areas on dorsal surface. To avoid confusion those on the ventral surface have been omitted.

Text-figure 3.—Enlarged view of head and anterior portion of body; ventral view, anatomy showing through.

Text-figure 4.—Region of a female aperture (dorsal view).

References to lettering:—C., collarette; cor., corona; f.b., foreign body?; o., ovum; r.s., receptaculum seminis; t.s., tail septum; v.g., ventral ganglion; v.s., vesicula seminalis.